The Advanced Superconducting Test Accelerator (ASTA) facility at Fermilab

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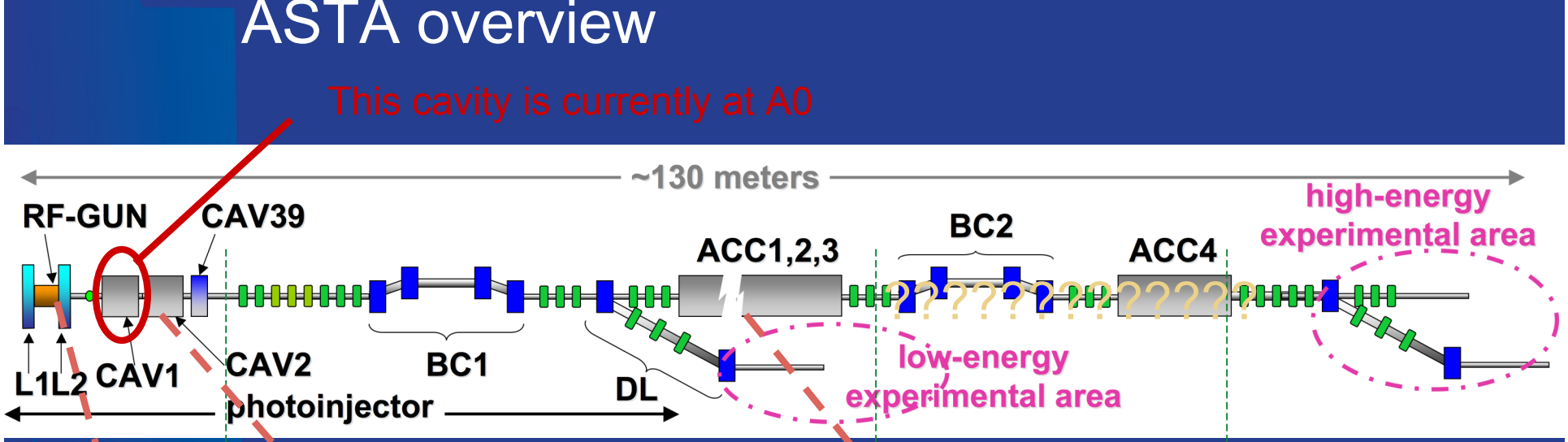
Fermilab

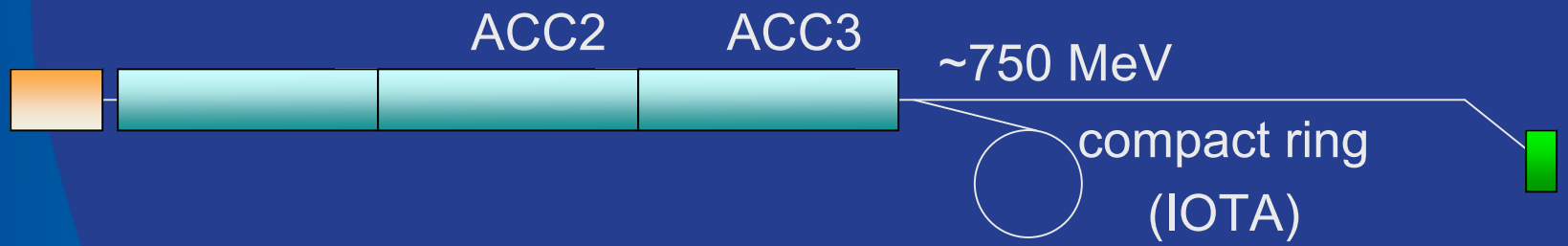
ASTA overview



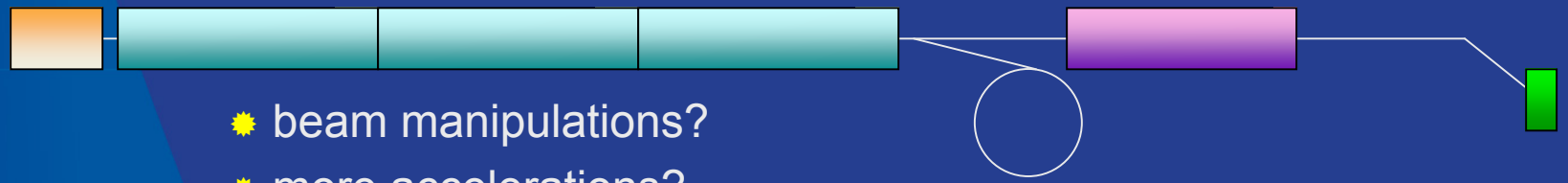
ASTA phases

- **FY12: photoinjector commissioning +250 MeV**

- **FY 13-14: install commission ACC2+3**

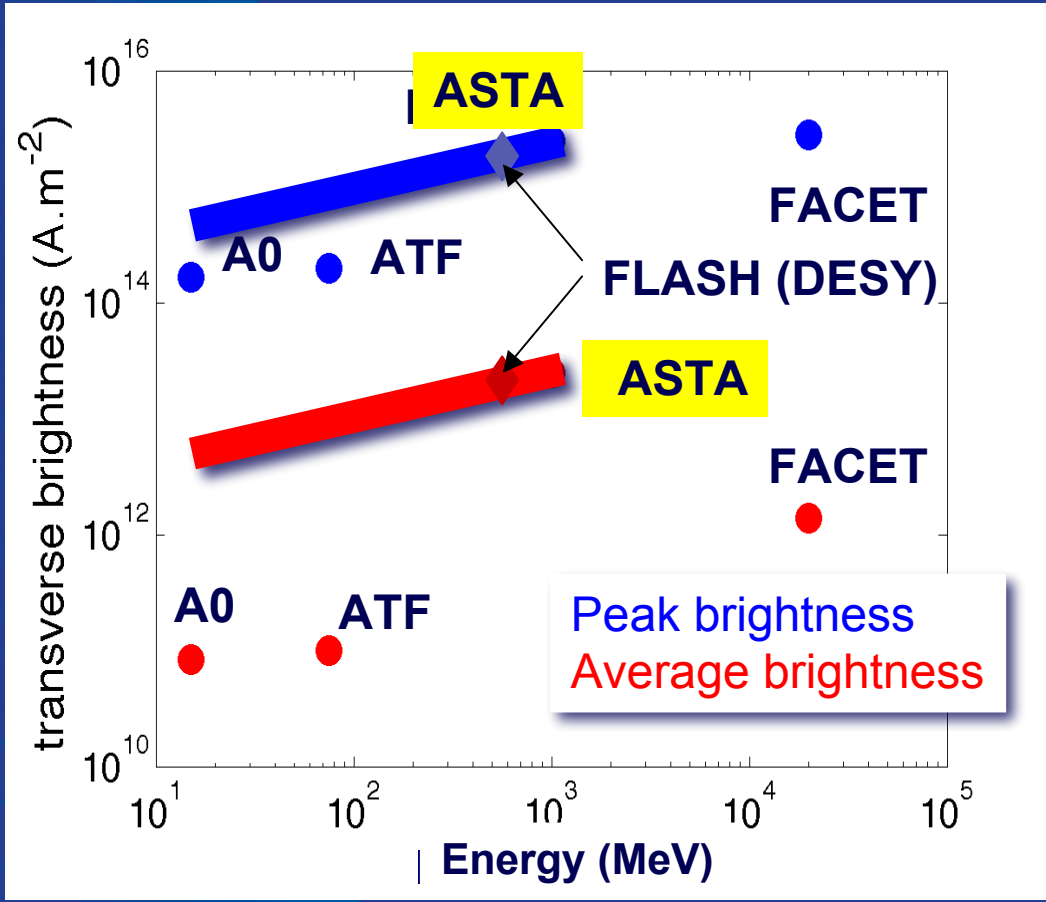


- **FY 15: 750 MeV beam to "users"**



- beam manipulations?
- more accelerations?

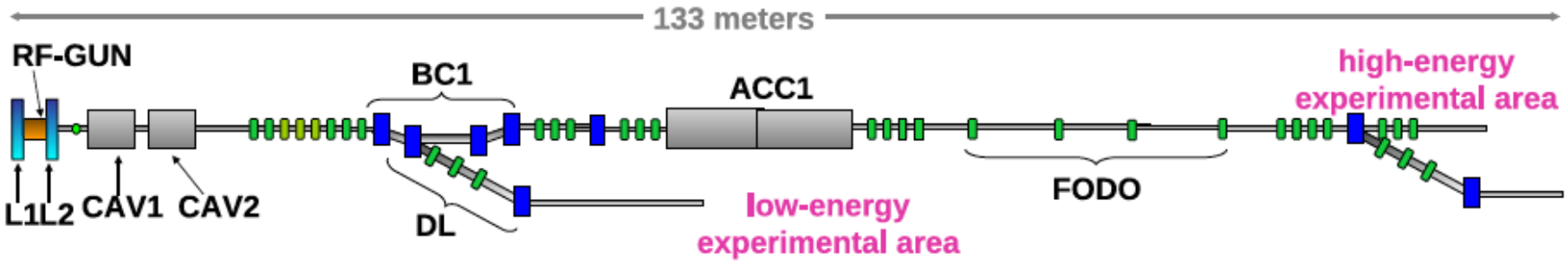
ASTA promise…



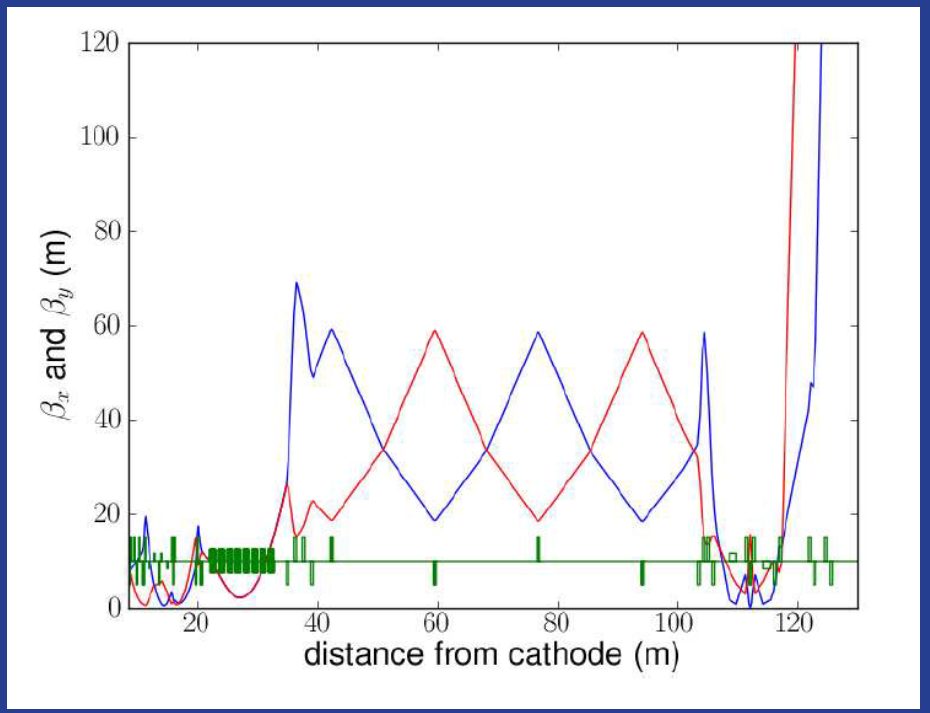
(ASTA performances are extrapolated from simulations of injector -- these are the best possible performances)

- Variable energy from ~40 to ~1 GeV,
- High-repetition rate (1-ms trains):
  - Exploration of dynamical effects in beam-driven acceleration methods.
- L-band SCRF linac:
  - Well suited for beam-driven acceleration,
- Photoinjector source:
  - Provides low-emittance beam,
- Arbitrary emittance partition:
  - repartition of phase spaces to match final applications,
  - Tailored current profiles.

Accelerator configuration for 1st beam



- Only one accelerating module available for first beam,
- Transport from cryomodule exit to spectrometer line with FODO
- High-energy spectrometer + user beamline(s)
- Off-axis dump to accommo-date possible extensions



[C. Prokop, et al., (2011)]

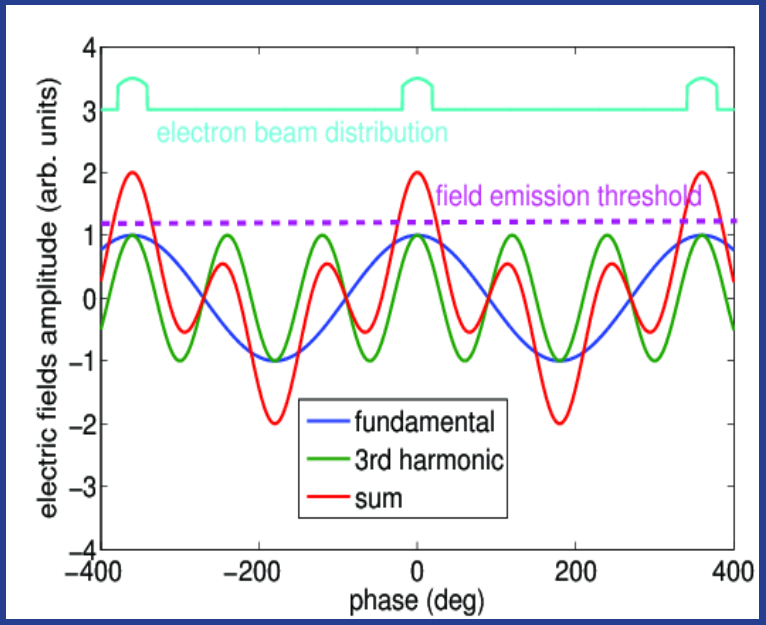
Initial research themes:

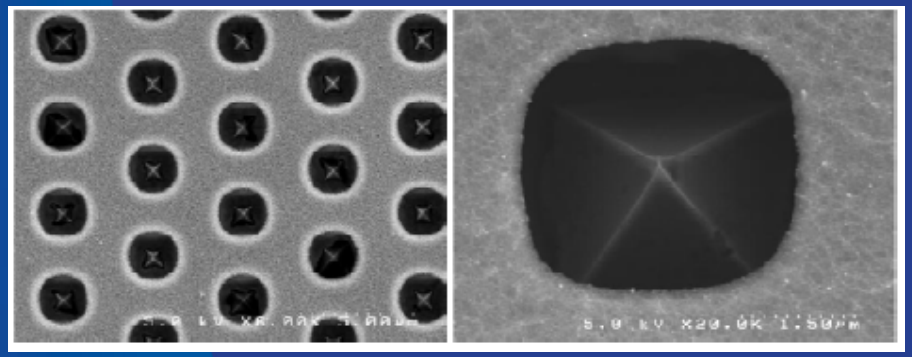
- Beam dynamics
  - Photoinjector characterization,
  - Low energy compression.
- Advanced phase space manipulations:
  - Flat beams and their compression,
  - Transverse-to-longitudinal phase space exchange (PEX),
  - Arbitrary repartitioning of emittances (flat beam + PEX)
- High-brightness electron beams
  - Channeling radiation (with Vanderbilt),
- Integrable-Optics Test Accelerator (Valishev's et al.)
  - Small diameter ring downtream of cryomodule to test integrable optics concept.

High-Brightness e- beams: possible production of field-emitted bunches

- During FY12-13, HBESL will support the development of a coaxial-line cathode holder
- Two-frequency gating of field emitters
- If successful this system could be used at ASTA

[J. Lewellen, PRSTAB 2006]

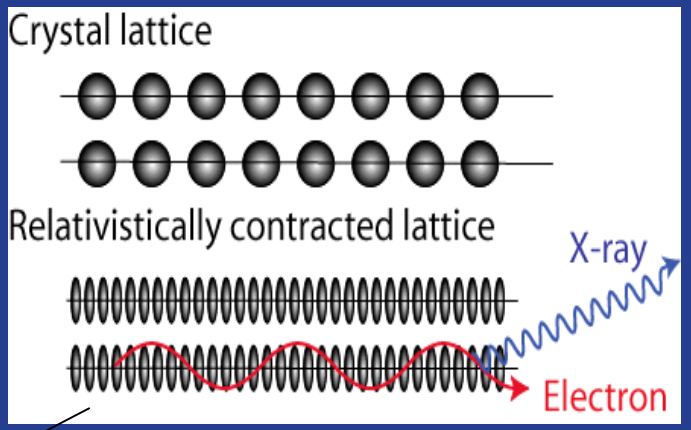


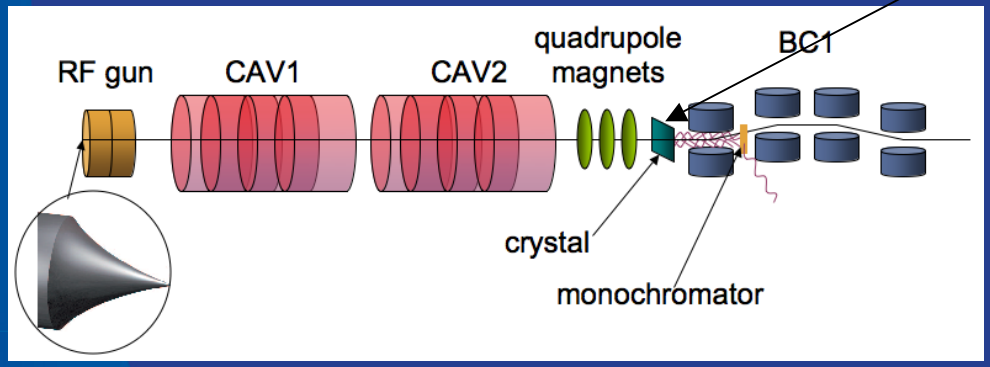


[collaboration with Vanderbilt and NIU (funded by DARPA)]

High-Brightness e- beam: applications to X-ray sources

- Bright electron beams from single-tip FE are planned to be used to produce X-rays via channeling radiation
- Expected brightness for 15 keV ~10^{12} photons/s-mm^2-mrad^2-0.1% BW
- Need 40 MeV bunches on a diamond crystal with ~1000 e-



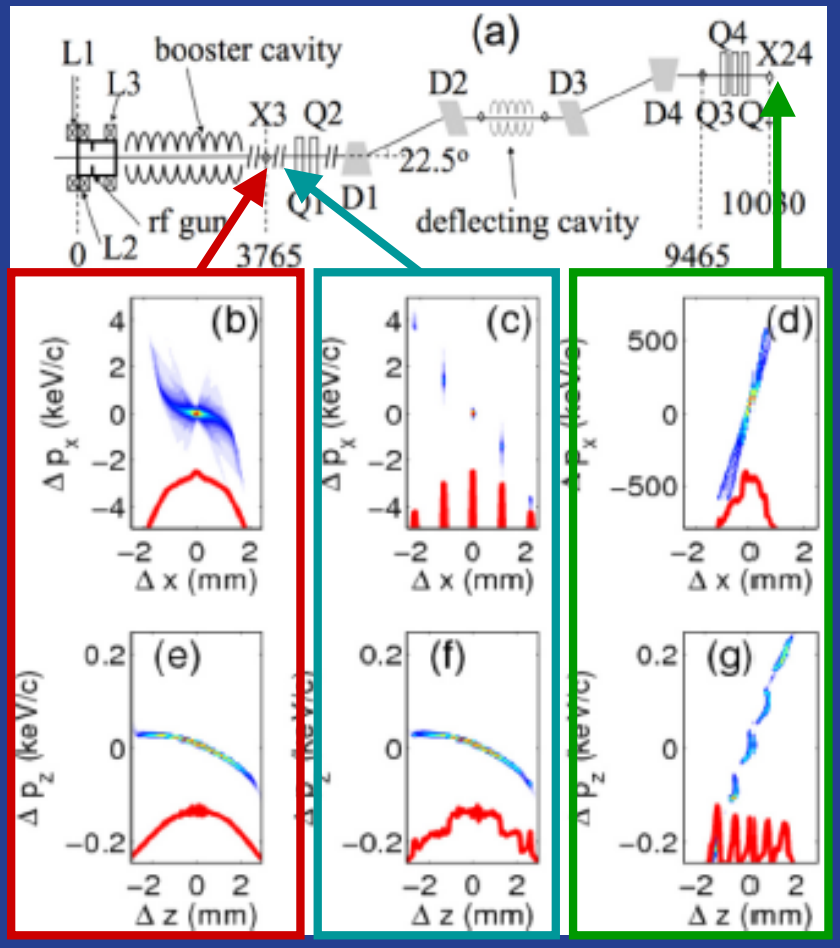


[C. Brau et al, to appear in Sync. Rad. News (2012)]

- FE array cathodes could also be used to increase charge/bunch or open new manipulation opportunities (combination with phase space exchangers)

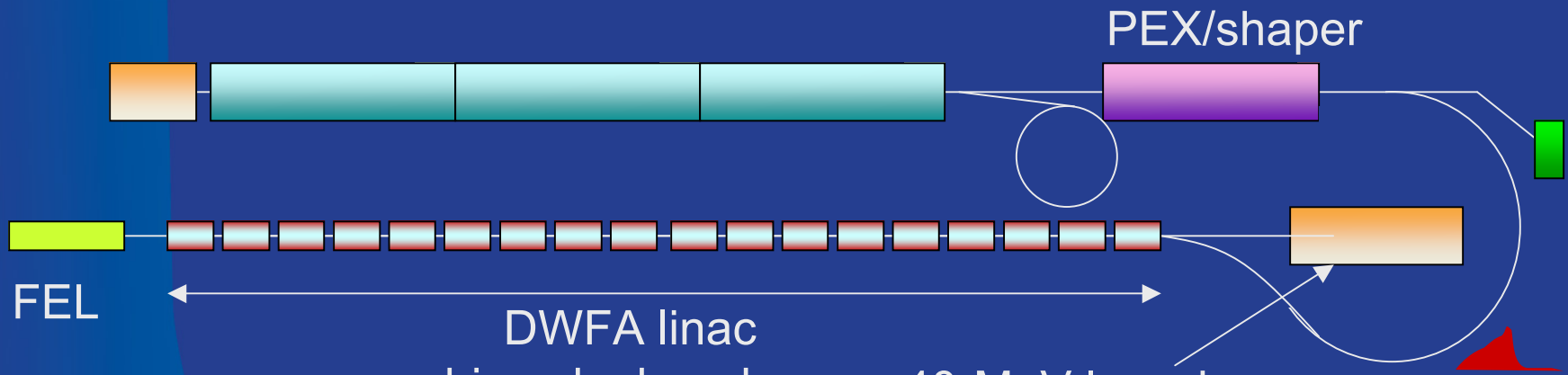
Next generations phase-space exchange (PEX) experiments

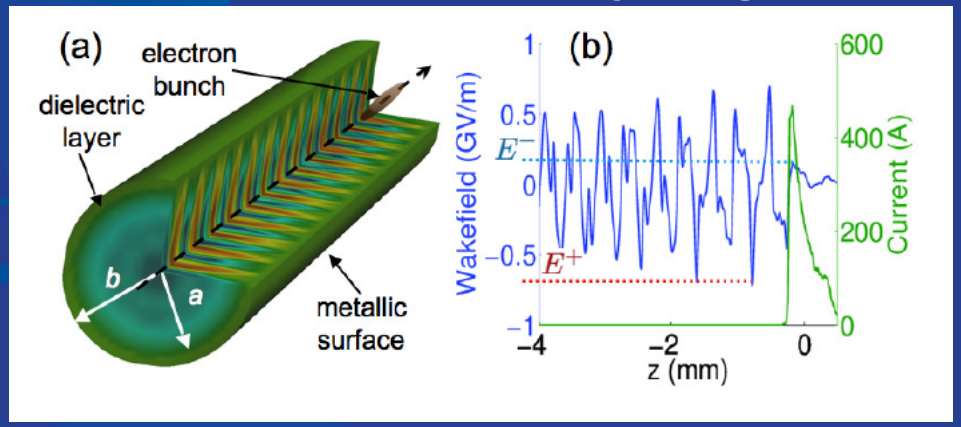
- Precise control of phase spaces
- Phase space exchange between two degrees of freedom was pioneered at Fermilab (A0 photoinjector)
- At ASTA we plan on pursuing and applying this concept to advanced acceleration techniques and novel accelerator-based light sources



Towards next generation light sources

- Combining Fermilab's phase space manipulation expertise with novel acceleration schemes
- Compact short-wavelength (soft x-ray?) FEL

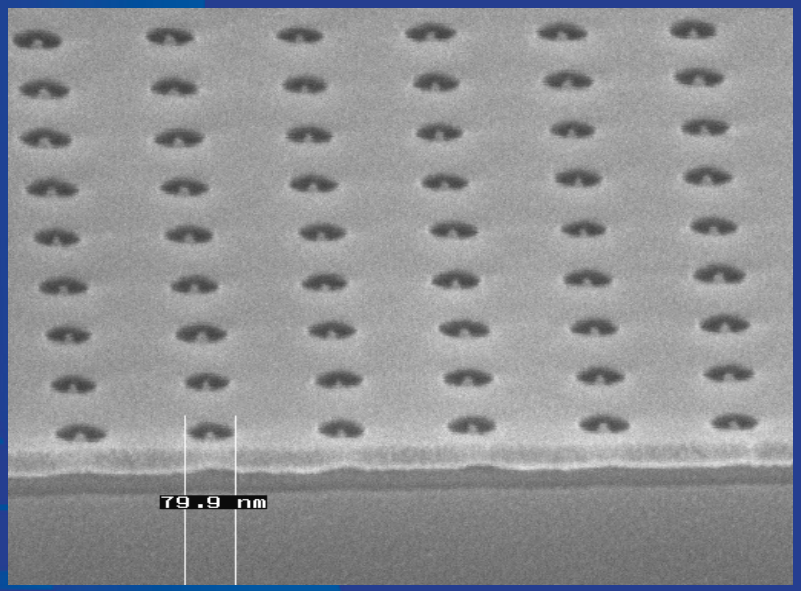




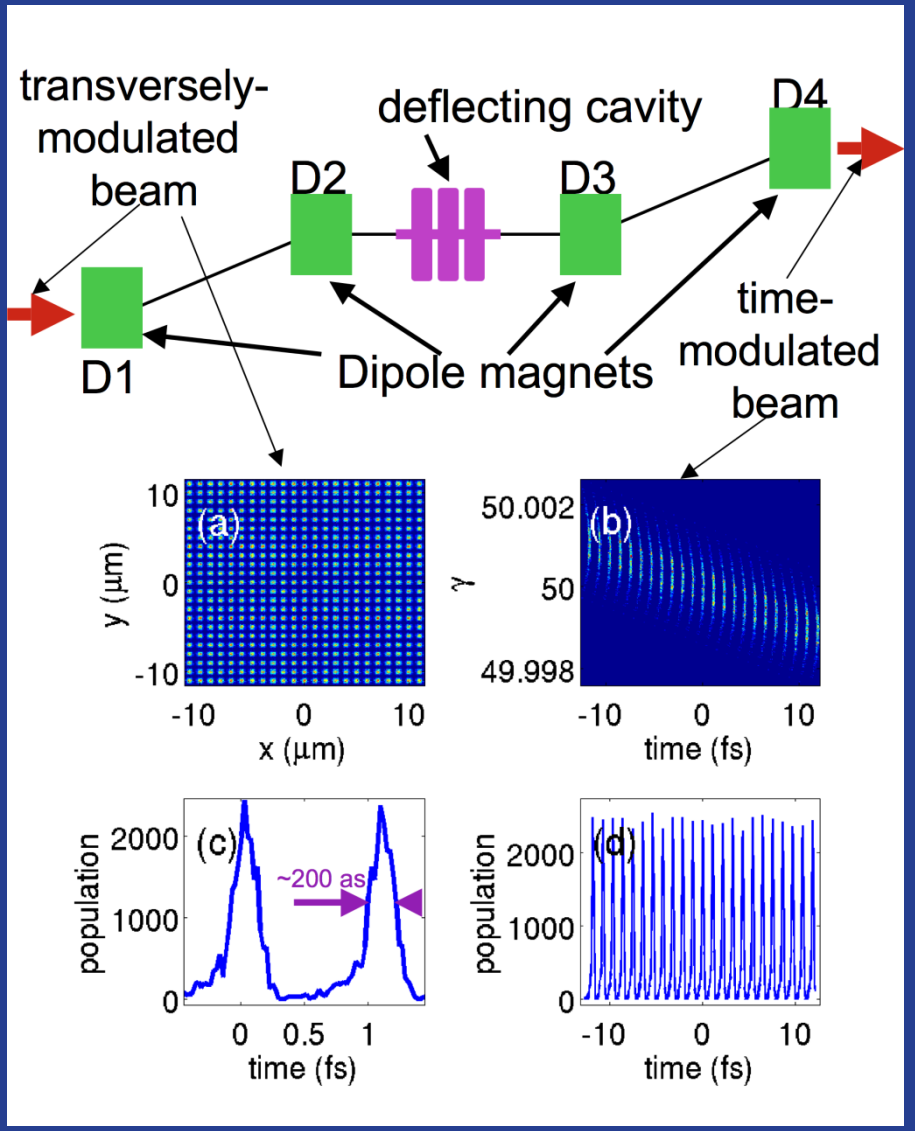
(adapted from Jing, Power, and Zholents APS/ANL)

Combining field emitters with PEX beamlines

- Generation of train of attosecond bunches,
- Applications to short wavelength light sources (FEL, ICS,…)

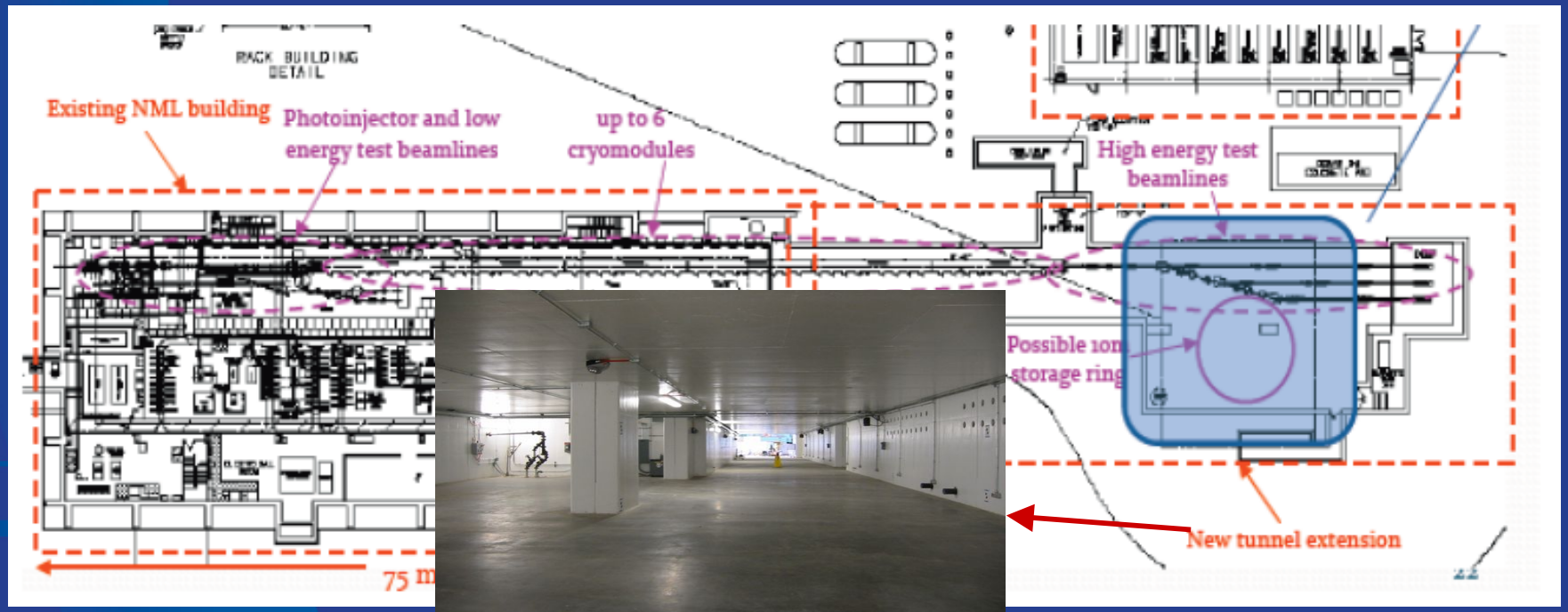


[Graves, Kaertner, Moncton, Piot to be published (2011)]

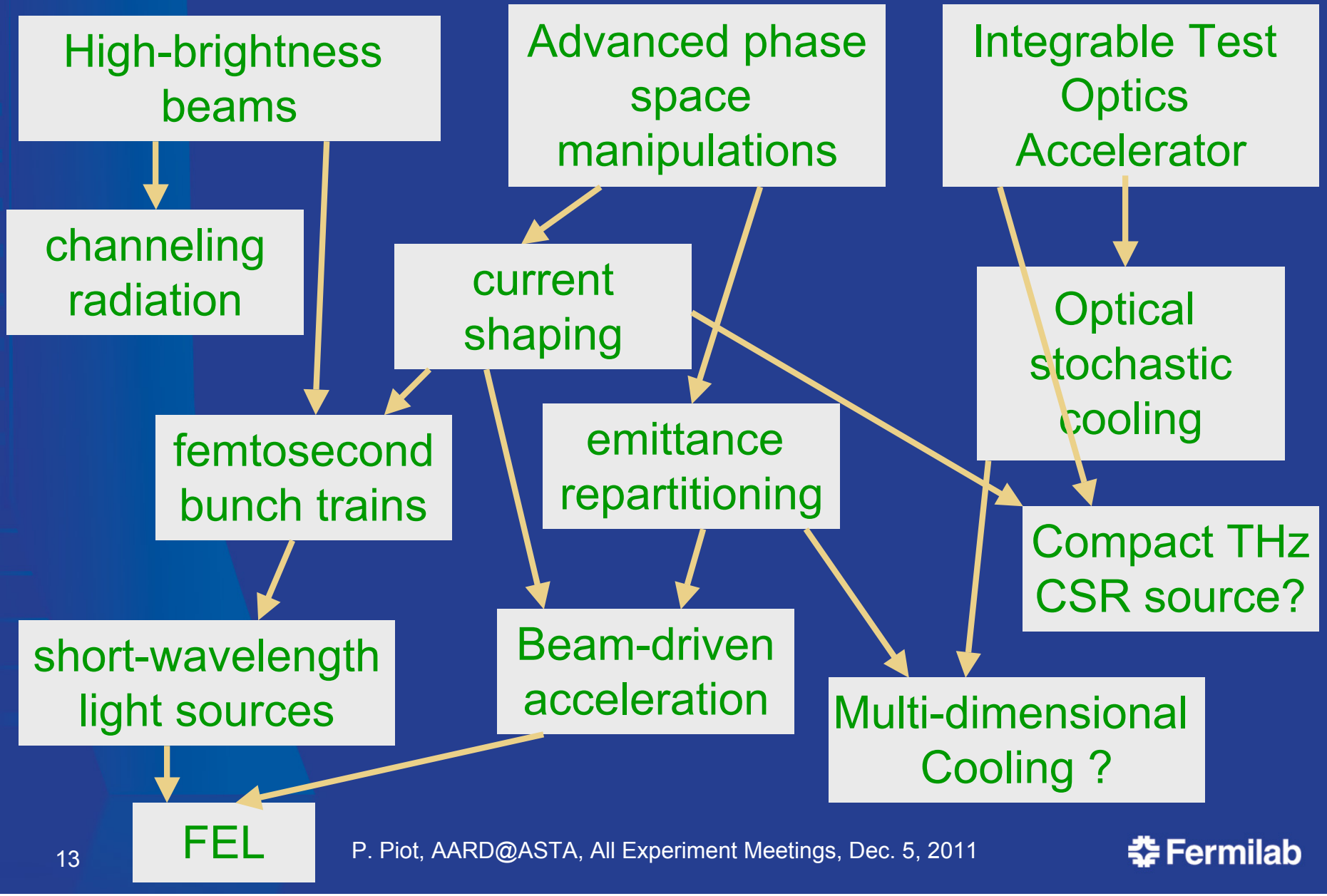


Integrable-Optics Test Accelerator

- ASTA facility provides the needed infrastructure to test other concepts,
- IOTA, a compact ring dedicated to test integrable optic (with ORNL),
- No stringent requirements on ~150-MeV beam quality,
- Can support experiment of optical stochastic cooling. (with MIT)



Further developments



Summary

- Over the last decade, Fermilab has been an active player in photoinjector R&D and application to AARD:
  - e- source for linear collider + short-wavelength FELs,
  - novel phase space manipulations: flat beam, emittance exchange, current tailoring technique.
- Phase space manipulations pioneered at A0PI have many applications: beam-driven acceleration, light sources, …

- ASTA: will incorporate most of these manipulations ⇒ flexible, powerful facility to support a vibrant AARD program
- A0PI: will be transformed into a high-brightness electron source laboratory (HBSEL): [A future talk at the AEM]
  - explore novel cathodes and acceleration concepts,
  - support gun R&D to improve the performances of ASTA.